PATENT SPECIFICATION

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COMPLETE SPECIFICATION

Improvements in and relating to Circuits Employing Condensers

We, THE BRITISH THOMSON-HOUSTON COMPANY, LIMITED, a British company having its registered office at Crown House, Aldwych, London, W.C.2, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

When condensers are connected to a live electric circuit a current impulse generally arises upon making the connection. This switching current impulse is diminished or damped when inductive or ohmic resistances are connected between the incoming condenser and the power source and such further condensers as may be already connected to the circuit. When, however, an additional condenser unit is connected in parallel with a comparatively large condenser battery already under voltage, practically the only damping means consists in such inductance and resistance as is involved in the short heavy connections between the incoming condenser and the battery of condensers already connected, together with the resistance of the spark at the switch contacts by which the circuit becomes completed before the switch is actually closed. These impedances are generally insignificant. Calculations show that the switching current is a maximum if the circuit is completed at the moment of peak value of voltage on the main condenser battery, and in practice the closing of the circuit must be assumed to occur approximately at this instant since the circuit will actually be closed by a spark jumping the switch contacts and this will occur at the point in the voltage wave referred to, in view of the limited switching speed.

In specification No. 422,809 there are described rectifying and inverting circuits including a grid controlled gas filled discharge device and a condenser connected across the device. Connected in series with the condenser is an inductive impedance having a value less than 1% of the capacitative impedance of the condenser. Here, the condenser constitutes on essential functional part of the circuit. The present invention consists in a method of connecting an additional condenser or condensers to an electrical circuit comprising a source of power and other condensers under voltage and the method according to the invention consists in connecting in series between each incoming condenser and the circuit an inductance having an impedance which at normal frequency lies between .001% and 1% of the capacitative impedance of the associated condenser.

It is known to diminish the current impulse when connecting additional condensers to a live electric circuit containing other condensers, by closing the circuit through a series resistance or through an inductance, the latter being either permitted to remain in circuit during operation or subsequently short-circuited. It has, however, hitherto been considered that to produce an adequate effect upon the current impulse a relatively high inductance is necessary, which naturally to a corresponding extent impairs the compensating effect desired from the condenser, and this has severely limited the useful scope of such series inductances. The invention is based upon the discovery that the amount of inductance hitherto included has been far too great.

It can be shown that if a condenser, in discharged condition and of capacity C farads, be connected to a bank of condensers of very much larger capacity, which at the moment is charged and at V volts, the resistance of the connection negligible and the inductance being L henries, the peak current will be in the neighbourhood of $V\sqrt{C/L}$.

If V and f represent respectively the peak value of the normal working voltage of the condenser and the normal working frequency in cycles per second, the peak value of current through the condenser after being connected will be $2\pi fVC$ and therefore if it is desired to limit the impulsive peak, which occurs upon connection, to a multiple of this peak value represented by the factor n, a value must be adopted for the inductance L, approximately given by:—

$$C/L = (n2\pi fC)^2$$

or, say by:—

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$$2\pi fL = \frac{1}{n^2}\,\frac{1}{2\pi fC}$$

The left-hand side of the last equation represents the harmful effect of the inductance when left in circuit, and the right-hand side, without the factor $\frac{1}{n^2}$, represents the inverse of the beneficial effect of the condenser. It is apparent that the harmful effect is inversely proportional to the square of the desired limit of peak current, and that consequently by taking a reasonably large value for this ratio n, the percentage of harmful effect, which thus depends upon the inverse square of a fairly large quantity, can be kept quite small.

In Fig. 1 there is plotted as ordinates the factor n and as abscissæ the ratio of the impedances (ignoring sign) at the working frequency f of the two portions of the circuit, namely the impedance of the inductance connected in series with the incoming condenser and the capacitative impedance of the condenser expressed as a percentage, and this percentage has been designated r.

It can be seen from the characteristic that for very small values of the ratio r, plotted as abscissæ the switching current impulse assumes values which are more than fifty times that of the normal current of the condenser. The curve shows, on the one hand, that it is possible with relatively low values of the inductive impedance to limit the maximum value of the switching current to relatively low values and that, on the other hand, with higher values of the inductance the limitation obtained of the switching current impulse no longer bears any significant relation to the inductance used. On the basis of this new perception the invention proposes to dimension the series-connected inductance so that its inductive impedance at normal frequency is below 1% of the capacitance impedance of the associated condenser phase and amounts preferably to about 0.25%. With the ratio $r = 0.5\%$, it is possible according to the characteristic in Fig. 1, for the ratio n to be limited to fifteen.

This limitation appears to be adequate in all cases, so that further measures for limiting the switching current impulse, such as a preliminary step resistance, becomes unnecessary in the switches provided. For switching, it is even possible to use power isolating switches which are provided with high-power fuses for the purpose of protection against excess current.

A further advantage of the arrangement according to the invention consists in that the fuse elements connected in series with the individual condenser units can be dimensioned with a view to greater protective effect for the condensers. Hitherto the limiting current intensity of such fuse elements has been dimensioned with a view to the switching current impulse being about 50 times the normal current of the associated condensers. By using the series choke dimensioned according to the invention it is possible to use fuses whose limiting current intensity is considerably reduced compared with that hitherto usual and which amounts only to about 10—20 times the nominal current of the individual condenser.

In view of the low value of the necessary reactance of the chokes, there are no objections to leaving the latter constantly connected in series with the condenser. This applies especially when it is considered that the capacity tolerance according to recognized regulations amounts to about 10%, so that therefore, a choke dimensioned according to the invention affects the capacity value to such a degree that it is safely within the tolerance limit.

Such low inductive values can readily be obtained with air core choke coils with small modifications which can very easily be accommodated under the cover of the condenser. If it is a question of oil condensers, then the choke coil will be arranged in the oil itself. Thereby a simple construction is obtained and by avoiding any disconnection of the choke coils during normal operations, also a safe operation.

It is particularly suitable to provide several groups of condensers each having its own series connected inductive impedance indicated at 14, according to Fig. 2. In this case, those condensers 1, 2 which are to be constantly connected to the system are connected through isolating switches 3, 4 to a bus-bar 5. The condensers 6, 7 on the other hand, which are inserted or cut out as required, are connected to the system through power isolating switches 8, 9. As common switch, a power switch 10 is provided on which acts an excess current relay 12 connected to a current transformer 11. All the switches are formed without series resistances, since the chokes built into the condensers cause sufficient limitation of the switching current impulse. The switching outputs of the regulating units can readily be coped with by power isolating switches, so that only a single power switch 10 is necessary.

Having now particularly described and ascertained the nature of our said inven-

tion and in what manner the same is to be performed, we declare that what we claim is:—

1. Method of connecting an additional condenser or condensers to an electric circuit comprising a source of power and other condensers under voltage, said method consisting in connecting in series between each incoming condenser and the circuit an inductance having an impedance which at normal frequency lies between .001% and 1% of the capacitative impedance of the associated condenser.

2. The method according to Claim 1, in which the impedance of the inductance amounts to from 0.25% to 0.5% of the capacitative impedance ofthe condenser.

3. The method according to Claim 1, in which the inductances are constituted by coreless choke-coils accommodated in the condenser casing.

4. The method according to Claim 1, which includes connecting in series with the incoming condensers fuses, the current carrying capacity of which amounts to from 10 to 20 times the normal current of the associated condensers.

5. The method according to Claim 1, which includes providing switches without preliminary step resistances for connecting and disconnecting the condensers.

6. The method according to Claim 1 which consists in connecting several condensers, each provided with a series inductance and a separating switch, to form a group adapted to be connected to the circuit through a common power switch.

7. The method of connecting an additional condenser or condensers to an electric circuit, comprising a source of power and other condensers under voltage, substantially as hereinbefore described with reference to the accompanying drawings.

Dated this 20th day of May, 1936.

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Agent for the Applicants.

Reference has been directed, in pursuance of Section 7, sub-section (4), of the Patents and Designs Acts. 1907 to 1932, to Specification No. 422,809.

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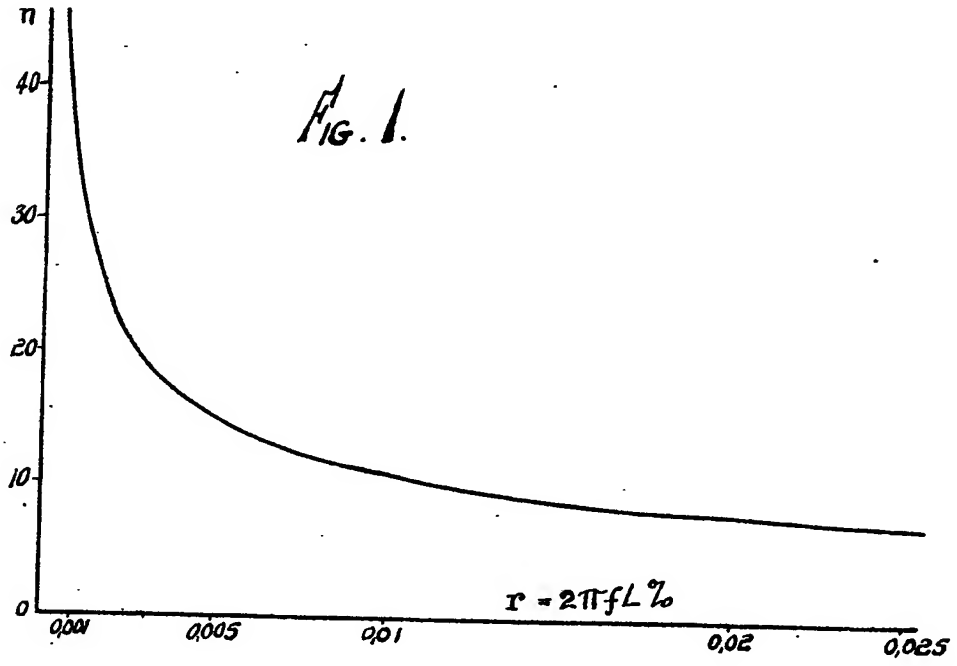
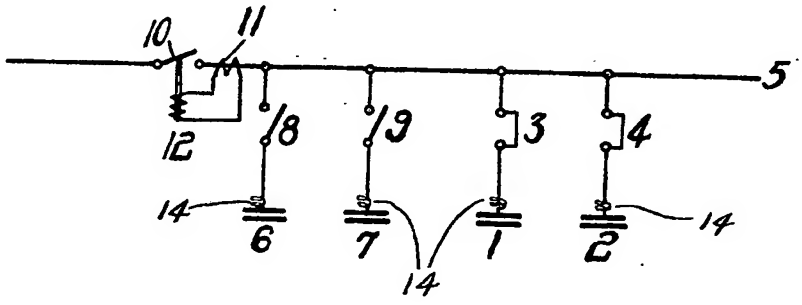


FIG. 1.

FIG. 2.



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